J. Raptor Res. 26(4):229–234

HOME RANGE AND ACTIVITY OF A PAIR OF BALD EAGLES BREEDING IN NORTHERN SASKATCHEWAN

JON M. GERRARD
Manitoba Institute of Cell Biology, 100 Olivia Street, Winnipeg, MB, Canada R3E 0V9

ALAN R. HARMATA
Department of Biology, Montana State University, Bozeman, MO 59717

P. NAOMI GERRARD
Box 113, R.R. 1, Headingly, MB, Canada R0H 0J0

ABSTRACT.—A male and female adult Bald Eagle (*Haliaeetus leucocephalus*) were radiotracked for 12 d during the summer of 1982. Size of the range and territory was 7 km^2 and 4 km^2, respectively. The female spent significantly more time within 200 m of the nest than the male, from 0400–1100 H. During the same period the male spent significantly more time flying than did the female. The greater proportion of time spent flying in early morning hours by the male may be a function of lower wing loading, facilitating energetically less expensive flight in the absence of updrafts and thermals. The results suggest that 400 locations of both members of a pair at 15 min intervals evenly distributed throughout the day, which is equivalent to 100 hr of observations, are adequate to describe 90% of the home range. The radio-tagged eagles usually responded only to intruders of the same sex.

Espacio habitado, y actividades de una pareja de Águila Cabeciblanca (*Haliaeetus leucocephalus*), en el norte de Saskatchewan

EXTRACTO.—Una pareja adulta de Águila Cabeciblanca (*Haliaeetus leucocephalus*) fue radiocontrolada por 12 días durante el verano de 1982. La extensión de área habitada y el territorio a defender fueron de 7 km^2 y 4 km^2 respectivamente. La hembra pasó significativamente más tiempo que el macho dentro de 200 m cerca del nido, entre las 0400 y las 1100 horas. Durante el mismo período el macho voló significativamente más tiempo que la hembra. La mayor proporción de tiempo gastado por el macho, en sus vuelos de las tempranas horas de la mañana, puede ser una función de las alas que son proporcionalmente más grandes en relación con el peso del cuerpo; lo que facilita energéticamente menos costosos vuelos en ausencia de termales y de vientos ascendentes.

Se observaron 400 ubicaciones consecutivas con 15 minutos de intervalo de ambos miembros de esta pareja de águilas, ello es equivalente a 100 h (igualmente distribuídas durante las horas del día) de observación con ambas águilas a la vista. Estos resultados son adecuados para describir el 90% de la extensión habitada por una pareja de *Haliaeetus leucocephalus* en su ciclo reproductivo. Estas radiocontroladas águilas generalmente respondieron sólo a intrusos del mismo sexo.

[Traducción de Eudoxio Paredes-Ruiz]

Previous studies have estimated territory size and home range of breeding Bald Eagles (*Haliaeetus leucocephalus*), but in most studies estimates were based on visual locations of unmarked eagles or linear distance between nests (e.g., Broley 1947, Hensel and Troyer 1964, Retfalvi 1965, Mattson 1974, Gerrard et al. 1980, Mahaffey 1981). Radiotelemetry permits identification of individual eagles, allows locating target eagles at will, and permits more precise definition of ranges and movements.

Understanding the relative roles of male and female Bald Eagles also has been difficult due to problems identifying unmarked individuals. Similarity in plumage has made definite and continuing identification of genders difficult. Size is the best criteria for distinguishing gender of eagles in the field, and although reasonably reliable when two eagles are together, gender assignment of solitary eagles is difficult. Radiotracking eagles of known gender allows identification and improves determination of the relative roles of male and female during the breeding cycle.

Table 1. Measurements of two mated adult Bald Eagles breeding at Besnard Lake, Saskatchewan in 1982.

MEASUREMENT	MALE	FEMALE	RATIO FEMALE/MALE
Weight (g)	3920	4540	1.15
Wing span (cm)	207	211	1.02
Wing area (cm^2)	5601	6014	1.07
Wing loading (g/cm^2)	0.70	0.75	1.07
Wing			
Chord (cm)	56.8	60.3	1.06
Flattened	59.7	61.6	1.03
Culmen length (mm)	49.4	55.0	1.11
Bill depth	33.2	35.6	1.07
Tarsus (mm)			
Largest width	14.4	17.0	1.18
Smallest width	13.3	16.5	1.24
Footpad (mm)	131.3	136.9	1.04

METHODS

A pair of Bald Eagles breeding on Besnard Lake were identified through previous study and chosen for radiotagging based on logistics and previous knowledge of habits (Gerrard et al. 1983, Gerrard and Bortolotti 1988). Eagles were captured by padded leg-hold traps placed in shallow water (0.1–0.3 m deep; Harmata 1985). Four or six capture devices were set around a Northern Pike (*Esox lucius*) or Walleye (*Stizostedion vitreum*) bait carcass staked in place. One capture site was in a shallow area with a mud and rock bottom in a wide shallow bay. Emergent vegetation surrounded the capture site to prevent the eagle from attempting to take the bait by air. Another capture site was on submerged rocks near the edge of a small rocky island which had several White Spruce (*Picea glauca*) used regularly by eagles for perching. Both capture sites were within 2 m of shore where adult eagles had caught fish previously.

Each capture adult was weighed and measured; a 54 gram radiotransmitter was attached to the two central tail feathers on each eagle. Wing area was measured after tracing the outline of the right wing onto a sheet. Wing outline was later transferred to graph paper with 1 mm squares. Area was determined by counting the number of inclusive and partially inclusive squares. Wing loading is the bird's weight divided by area of the two wings (Brown and Amadon 1968) and was here expressed as grams/cm^2.

Eagles were located using receivers and hand held yagi antennae, and observed with binoculars and spotting scope. Observations were nearly continuous during daylight hours during the first 2 d. After a one day hiatus, we located both eagles at 15 min intervals from 0415–2200 H for the next 9 d. At each sampling interval we determined the location and activity of both eagles and scanned with 10× binoculars and 20–45× spotting scope to locate other eagles. Most monitoring was from an elevated rock located 1.3 km southeast of the nest. This point permitted good visibility of many of the eagles' perch sites as well as the nest. During midday, when eagles were often soaring, a mobile tracker moved throughout the eagles' range to triangulate eagles when out of visible range. Visual contact with the radio-tagged eagles was made to verify the accuracy of the telemetry locations whenever possible. Range was determined using the minimum convex polygon method (Mohr 1947, Jennrich and Turner 1969). Territory was defined as the part of the range that was defended (i.e., from which other adult eagles were excluded, Pettingill 1970). Defended area was that enclosed by locations where we saw chase flights with one or other of the territorial pair chasing other eagles away. Activity and spatial relationships were calculated by dividing the number of 15 min observation records during which the eagle was flying and more than 200 m from the nest, respectively, by total records engaged in that activity for that hourly period. Total records per period was approximately 20 in each case (range 15–22).

RESULTS

A target pair of mated adult Bald Eagles breeding on Besnard Lake was captured in July 1982. The male was captured on 17 July at the Shallow Bay site and the female on 19 July at the Rocky Island site. Both eagles were caught the same day as respective capture sites were set.

Mensural data showed considerable difference in size between the two eagles. Greatest differences were in weight, culmen length, bill depth, and tarsal width (Table 1). Measurements of the larger eagle were well within those of known females and those of the smaller eagle were well within those of known males (Bortolotti 1984).

Radiotracking of the male began after release and continued through 0900 H 28 July 1982. Male and female eagles were monitored for 126 and 105 hr over 12 and 10 d, respectively. During this time, their nestlings were between 48 and 59 d old. Both eaglets fledged normally in early August 1982.

Range and Territory. Visual locations of eagles were obtained for 48% of 964 telemetry locations. Location of the eagle monitored were equivocal as to whether it was < or >200 m from the nest for 236 of 964 telemetry locations. Range for both eagles was 7 km^2, with no appreciable differences between the range of the male and that of the female (Fig. 1). Size of range in relation to cumulative number of observations is shown in Figure 2. There was little expansion in range size during the latter half of the observation period.

The defended area was a minimum of 4 km^2 but might have been larger, particularly as few inter-

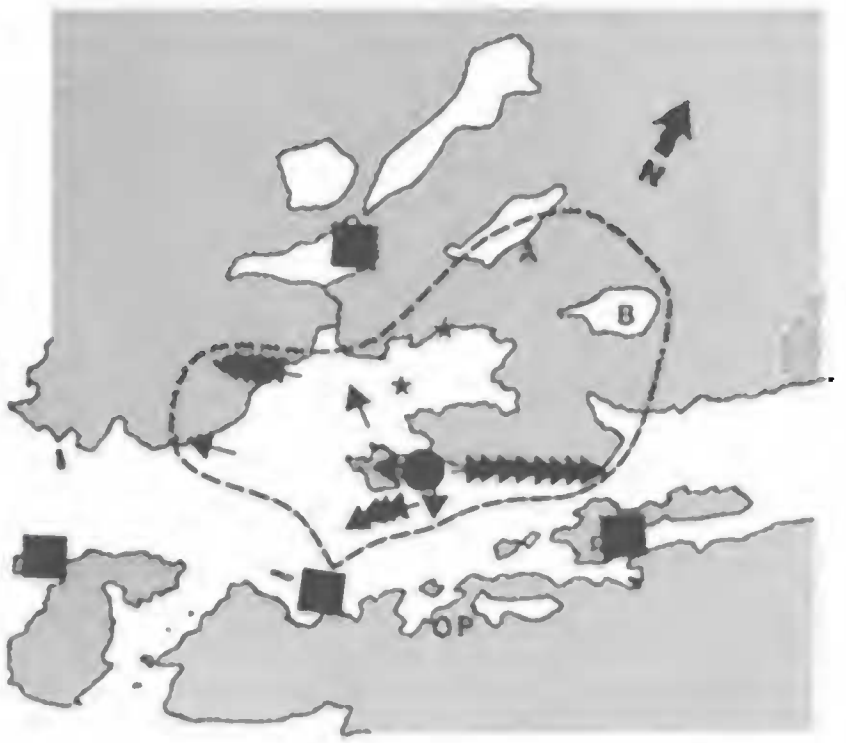

Figure 1. Range (7 km²) of a mated pair of radio-tagged Bald Eagles on Besnard Lake, Saskatchewan between 17–28 July 1982. Sightings of the male and female eagles were considered individually. The size of the range included the area encompassed by the outer extent of these flights. Symbols denote: ● nest of eagles equipped with radios, ■ nests of adjacent bald eagle pairs, → territorial defense flights by marked eagles; A, B small lakes visited by mated pair, * capture sites; OP observation hill.

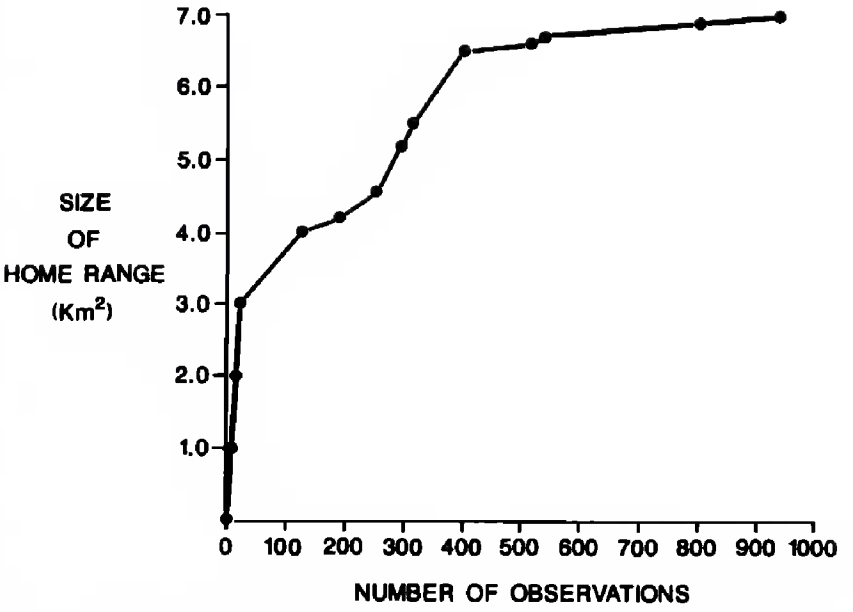

Figure 2. Size of home range of a mated pair of Bald Eagles radiotagged on Besnard Lake, Saskatchewan, in relation to cumulative number of locations.

actions were seen to the north of the nest. On three occasions when both male and female were near the nest, other adults entered the territory and perched on a small island 300 m from the nest. Size of the intruders indicated that all were females. On all three occasions, the male did not pursue the intruder but the female did. On four occasions, the male was involved in chasing and pursuing other eagles which entered the territory. Gender of intruding eagles was not determined during the latter encounters, although at least two were thought to be males.

Perching Behavior. One adult eagle was within 200 m of the nest most of the time. The female spent significantly more time within 200 m of the nest than the male from 0400–1100 H ($\chi^2 = 25.7$, $P < 0.01$; Table 2). There was no difference between male and female regarding distance from the nest from 1100–1800 H (Table 2) or from 1800–2200 H, except that the male tended to roost more than 200 m from the nest while the female roosted near the nest (Fig. 3). Both male and female used perches when near the nest. The male tended to perch on the topmost branch of the tallest spruce within 30 m of the nest (11.0% of time perched), or topmost branch of the tallest spruce on the nest island (5.2% of time perched). The female tended to perch on top of spruce trees which were slightly lower but did, on occasion, use the same perches as the male (4.7% and 0.5% of time perched, respectively). Both eagles spent a small proportion of their time away from the nest at the small lakes A and B away from Besnard Lake (4.9% for male, 6.1% for female; Fig. 1).

Activity Patterns. Activity of the eagle monitored (perched or flying) could not be determined for 228 (24%) of 964 telemetry locations. The data showed that female and male spent nearly equal time in flight, 18% and 17% respectively, but they distributed their activity differently between morning and midday. The male spent significantly more time fly-

Table 2. Spatial and temporal relationships of male and female Bald Eagles relative to their nest at Besnard Lake.

	Number of Locations	
Hours	Male	Female
0400–1100		
Within 200 m of nest	60 (31%)	93 (58%)
More than 200 m from nest	132 (69%)	67 (42%)
Total	192	160
1100–1800		
Within 200 m of nest	91 (43%)	64 (41%)
More than 200 m from nest	121 (57%)	94 (59%)
Total	212	158

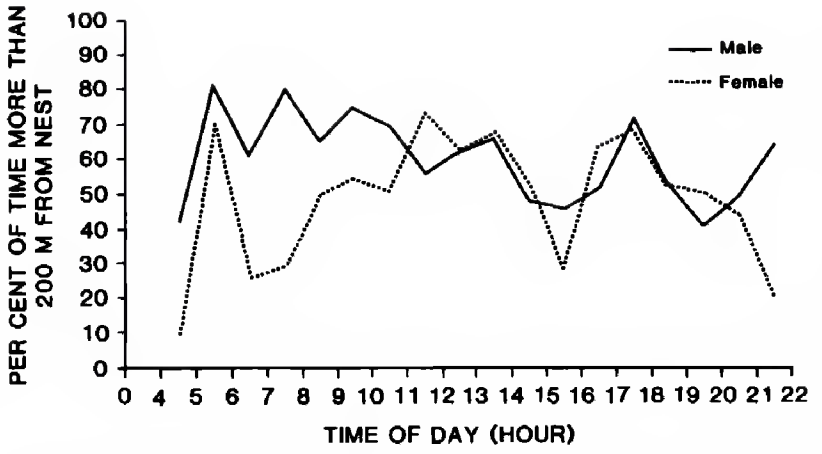

Figure 3. Location of male (——) and female (·····) Bald Eagles in relation to the location of their nest at Besnard Lake, Saskatchewan by hour of the day. Total records were approximately 20/hr.

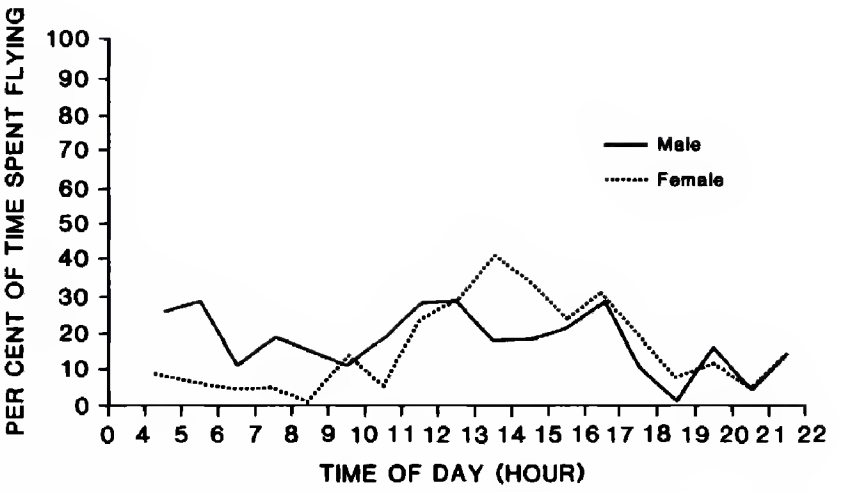

Figure 4. Percent time the radio-tagged male (——) and female (·····) Bald Eagle engaged in flight by hour of day. Total records were approximately 20/hr.

ing in early morning than did the female ($\chi^2 = 8.1$, $P < 0.01$; Table 3). There was no signficant difference in amount of time spent flying by male or female during midday, although the female tended to fly longer and/or more often (Table 3). In the evening (1800–2200 H), the flying activity of the male and female was similar (Fig. 4).

DISCUSSION

Movements and activities of radio-tagged eagles suggested little effect of capture, handling, and monitoring on normal behavior. Upon release, the male immediately flew to perch on a tall tree on the nest island. Within 2.5 hr of release, the male had chased both an intruding immature and an intruding adult Bald Eagle and then caught a fish which it brought back to the nest. Capture and handling may have affected the female briefly, however. When released at 0820 H she did not return to the nest immediately, but flew to a perch near the small lake (B; Fig. 1) over 2 km from the nest and remained there until 1125 H. This may not have been normal behavior. Subsequent monitoring indicated that she was more often within 200 m of the nest during the morning hours. However, within 4 hr both radio-tagged eagles were using their usual perches near the nest and both the young fledged normally. Research activities apparently had no effect on habitat use or productivity.

Table 3. Relative activity of male and female Bald Eagles in early morning and during midday at Besnard Lake.

	NUMBER OF LOCATIONS	
HOURS	MALE	FEMALE
0400–1100		
Flying	29 (15%)	9 (6%)
Perched	164 (85%)	152 (94%)
Total	193	161
1100–1800		
Flying	46 (21%)	46 (28%)
Perched	172 (79%)	118 (72%)
Total	218	164

Mensural data illustrated the normal size dimorphism in a mated pair of Bald Eagles. Proportionally, weight was greater for the female than wingspan and wing area, resulting in a higher wing loading. Wing loading values suggest active flight may be more energetically expensive in calm air for females than for males. Indeed, the male spent more time flying early in the day when the thermals were weaker (or non-existent). Both male and female spent considerable time flying during mid-day when thermals were strongest. Results were similar to Bald Eagle activity patterns on wintering grounds, where males tended to be active earlier and over a greater part of the day than females (Harmata 1984).

Consistent with the observation that the female was less active in the morning, she also spent more time within 200 m of the nest between 0400–1100 H. Although some bias may exist due to the proportion of locations where we did not unequivocally establish whether an eagle was more or less than 200 m from the nest or flying versus perched, we have no reason to suspect this would have differentially affected the data for males versus females. Indeed, our visual confirmation of 48% of all locations provided a reasonable corroboration of the reliability of the data. Additionally, signal characteristics differed noticeably between flying and perched eagles. Therefore, assessment of activity for eagles

out of visual range could be determined relative to signal type and receiving antenna position during strongest signal (horizontal = flying, vertical = perched).

Responses of radio-tagged eagles to intruders indicated gender-specific defense of territory. The female clearly reacted to other females but ignored eagles we thought to be males. The opposite appeared to be true for the male. Gender specific defense of territory has been noted in Golden Eagles (*Aquila chrysaetos*) and would facilitate rapid replacement of lost mates (Harmata 1982).

Home ranges of Bald Eagles vary from an estimated 10–15 km^2 for other adult eagles on Besnard Lake (Gerrard et al. 1980) to about 30 km^2 used by a pair of eagles on the San Juan Islands in Washington (Retfalvi 1965) to a mean range of 47.5 km^2 in the Greater Yellowstone Ecosystem (Harmata and Oakleaf 1991). Home ranges in the Greater Yellowstone Ecosystem were annual ranges, and this may explain the relatively large differences in relation to other estimates made during the breeding season. Size of the defended area (about 4 km^2) did not differ appreciably from an estimated 6 km^2 for a pair farther southwest on Besnard Lake, but did differ from estimates of 1.5–2.0 km^2 in Florida and Michigan (Broley 1947, Mattson 1974).

Four other pairs of eagles nested successfully in close proximity to the monitored pair (Fig. 1). These four nests were previously recorded in this region of the lake and may have induced the slightly smaller territory size relative to estimates from elsewhere on the lake in 1978 (Gerrard et al. 1980). Our findings that perches may be preferentially used by one eagle of a pair is similar to that of Retfalvi (1965) and illustrate the importance of adequately describing Bald Eagle ranges for management purposes.

Precise size of the home range of Bald Eagles may depend on available food supply and proximity of neighboring eagles. Range utilized may also vary with season, time of the breeding cycle and nesting habitat (river, lake or marine). Range size also is a function of monitoring time. Figure 2 shows little increase in size of the range after 400 observation points were accrued, suggesting that by this point we were close to determining the maximum extent of the home range.

Several recovery and management plans for the Bald Eagle in the United States suggest the development of site- or pair-specific management plans for each nesting pair before "delisting" from endangered status should occur (e.g., Pacific Bald Eagle Recovery Plan, USFWS 1986, and Montana Bald Eagle Management Plan, MBEWG 1986). The utility of site plans for effective management has been slow because the management strategy was based on an inadequate description of range and habitat use. Data deficiencies were mostly a consequence of insufficient monitoring effort, spawned by a lack of guidelines.

In this study, 400 consecutive 15 min telemetry locations determined 93% of the range of a pair of Bald Eagles. Doubling the effort added only 7% to range size (Fig. 1). Therefore, a minimum of 400 telemetry locations, accrued consecutively at 15 min intervals over daylight hours, or 100 hr of observation with both eagles in view, distributed evenly throughout daylight hours may be used as a guideline for observational effort. This effort should delineate over 90% of a range of breeding Bald Eagles and provide adequate data for site- or pair-specific management purposes, at least on lakes.

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Received 22 June 1990; accepted 20 August 1992